

FIELD OF THE INVENTION

The subject of the present invention is a new genetic material encoding a new protein recognized by anti-Trypanosoma cruzi antisera, and it relates to the use of said gene and protein, especially for diagnostic, pharmaceutical and therapeutic purposes.

Trypanosoma cruzi is a flagellate protozoal parasite, a member of the order Kinetoplastida and of the family Trypanosomatidae, which is responsible for Chagas disease which affects naturally millions of persons, mainly in Latin America.

In vertebrate hosts, Trypanosoma cruzi is present in two forms: one which is mobile by means of its flagellum or trypomastigote and which does not divide; the other is aflagellate, or intracellular amastigote, which multiplies by binary division.

Transmission of the protozoan in man occurs through hematophagous insects of the family Reduviidae, during a blood meal followed by dejections at the site of the bite. The vector insect thus releases the infectious metacyclic trypomastigote forms which will colonize many cell types through the blood circulation. Trypanosoma cruzi infects cardiac and skeletal muscular cells, the glial cells and the cells of the mononuclear phagocytic system. After passive penetration into the host cell, the trypomastigote form of the parasite differentiates into the amastigote form, divides actively and then this is followed by a release of the trypomastigote forms, thereby causing a new cell invasion.

The insects will complete the parasitic cycle by ingesting, during a blood meal, the trypomastigote forms in the host. The latter differentiate into

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~~epimastigote~~  
~~epimastigote~~ forms in the vector's middle intestine and finally into the infectious metacyclic trypomastigote forms in the posterior intestine.

Two phases can be distinguished in the Chagas  
5 disease: the acute phase and the chronic phase. The acute phase occurs after a transfusional, congenital or vectorial type contamination and lasts for a few weeks. It is characterized by a large number of parasites circulating in the blood and corresponds to an expo-  
10 nential division of the protozoan. The acute phase is most often asymptomatic. However, in infants contaminated by their mother, the acute phase, which is marked by an acute cardiopathy, may be critical. The chronic phase may extend over many years. In some indi-  
15 viduals, this phase is asymptomatic. On the other hand, other patients have tissue lesions in the heart or digestive type manifestations. In any case, clinical diagnosis must always be confirmed by tests for the detection either of antibodies directed against the  
20 parasitic antigens, or of the parasite itself.

This disease is becoming a worldwide problem because of the contamination through blood transfusion. It was therefore becoming essential to have available diagnostic tests which make it possible to determine  
25 the presence of the parasite in individuals. Various serological ~~tests, such as~~ *tests include* direct agglutination, indirect immunofluorescence (IIF), complement fixation tests (CFR), ELISA tests (Enzyme Linked Immunosorbent Assay). The Trypanosoma cruzi antigens used for the  
30 serological tests are obtained from a total lysate of the noninfectious stage of the parasite or from partially purified protein fractions. However, these

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fractions do not allow antigens to be obtained in sufficient quantity and quality for the production of a reliable serological diagnostic test. Furthermore, the complexity of the parasite and the strain-to-strain antigenic polymorphism introduce an additional difficulty in the reproducibility of the different preparations. Finally, there are many risks of cross-reactivity with other protozoa, more particularly with *Trypanosoma rangeli*, a nonpathogenic parasite, and the family *Leishmania*. Another disadvantage of these techniques is the absence of determination of the disease phase which would allow a treatment from the onset of the acute phase.

In order to solve these various problems, it was envisaged to produce a serological diagnostic kit composed of recombinant proteins which would be specific for *Trypanosoma cruzi*.

Various research groups have screened libraries for expression of *Trypanosoma cruzi* genomic DNA or complementary DNA in the vector  $\lambda$ gt11, using sera from patients suffering from Chagas disease. The  $\lambda$ gt11 phage allows the insertion of foreign DNA of a maximum size of 7Kb into the *Eco*R1 site localized in the *lacZ* gene, under the control of the *lac* promoter. The product obtained is a recombinant protein used with beta-galactosidase, which is inducible by IPTG (isopropyl beta-D-thiogalactoside).

Various *Trypanosoma cruzi* genes, encoding proteins recognized by the Chagasic sera <sup>were</sup> ~~where~~ thus characterized. Among the recombinant antigens described, the H49 antigen may be mentioned (Paranhos et al., 1994 (1)). However, this antigen does not allow a

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B Serological  
~~sero-logical~~ detection sensitivity of 100% of the  
patients in the acute or chronic phase. It was  
therefore envisaged to combine the H49 antigen with the  
CRA antigen ~~anti-gen~~ (Cytoplasmic Repetitive Antigen) (Lafaille  
5 et al., (1989) (2)) but still without solving this  
problem.

B SUMMARY OF THE INVENTION

The present inventors have identified and  
obtained for the first time a new genetic material  
encoding a new protein, recognized by anti-Trypanosoma  
10 cruzi antisera, which makes it possible to overcome the  
abovementioned disadvantages. The genetic material may  
be used to produce proteins or polypeptides for the  
production of diagnostic tests, or for the preparation  
of vaccinal or pharmaceutical compositions, or may  
15 itself either be used as a probe, or for the deter-  
mination of specific probes which can be used in  
nucleic acid hybridization tests for the detection of  
Trypanosoma cruzi infections. Likewise, the protein or  
any corresponding polypeptide may be used for the pro-  
20 duction of antibodies specific for the parasite, for  
diagnostic or passive protection purposes.

B DETAILED DESCRIPTION OF THE INVENTION  
This gene was called Tc 100 by the applicant.

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Consequently, the subject of the present  
invention is a DNA or RNA molecule consisting of at  
25 least one strand comprising a nucleotide sequence  
represented in the identifier SEQ ID <sup>NO:1</sup> ~~No.1~~, or a  
sequence complementary or antisense or equivalent to  
said sequence identified in the identifier SEQ ID <sup>NO:1</sup> ~~No.1~~,  
and especially a sequence having, for any succession of  
30 100 contiguous monomers, at least 50%, preferably at  
least 60%, or better still at least 85% homology with  
said sequence.

B Nucleotide sequence is understood to mean either a DNA strand or its complementary strand, or an RNA strand or its antisense strand or their corresponding complementary DNAs. The DNA sequence as represented in the identifier SEQ ID <sup>NO. 1</sup> ~~No. 1~~ corresponds to the messenger RNA sequence, it being understood that the thymine (T) in the DNA is replaced by a uracil (U) in the RNA.

10 According to the invention, two nucleotide sequences are said to be equivalent in relation to each other, or in relation to a reference sequence if, functionally, the corresponding biopolymers can play essentially the same role, without being identical, with respect to the application or use considered, or in the technique in which they are involved; two sequences 15 obtained because of the natural variability, especially spontaneous mutation, of the species from which they were identified, or because of induced variability, as well as homologous sequences, homology being defined 20 below, are especially equivalent.

Variability is understood to mean any spontaneous or induced modification of a sequence, especially by substitution and/or insertion and/or deletion of nucleotides and/or of nucleotide fragments, 25 and/or extension and/or shortening of the sequence at at least one of the ends; a nonnatural variability may result from the genetic engineering techniques used; this variability may result in modifications of any starting sequence, considered as reference, and capable 30 of being expressed by a degree of homology relative to the said reference sequence.

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Homology characterizes the degree of identity of two nucleotide (or peptide) fragments compared; it is measured by the percentage identity which is especially determined by direct comparison of nucleotide (or peptide) sequences, relative to reference nucleotide (or peptide) sequences.

Any nucleotide fragment is said to be equivalent to a reference fragment if it has a nucleotide sequence which is equivalent to the reference sequence; according to the preceding definition, the following are especially equivalent to a reference nucleotide fragment:

a) any fragment capable of at least partially hybridizing with the complementary strand of the reference fragment,

b) any fragment whose alignment with the reference fragment leads to the detection of identical contiguous bases, in greater number than with any other fragment obtained from another taxonomic group,

c) any fragment resulting or capable of resulting from the natural variability of the species, from which it is obtained,

d) any fragment capable of resulting from the genetic engineering techniques applied to the reference fragment,

e) any fragment, containing at least 30 contiguous nucleotides, encoding a peptide homologous or identical to the peptide encoded by the reference fragment,

f) any fragment different from the reference fragment by insertion, deletion, substitution of at least one monomer, extension or shortening at at least

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one of its ends; for example any fragment corresponding to the reference fragment flanked at at least one of its ends by a nucleotide sequence not encoding a polypeptide.

5           The invention moreover relates to DNA or RNA fragments whose nucleotide sequence is identical, complementary, antisense or equivalent to any one of the following sequences:

10           - that starting at nucleotide 1232 and ending at nucleotide 2207 of SEQ ID ~~No. 1~~ <sup>NO:1</sup>

            - that starting at nucleotide 1232 and ending at nucleotide 1825 of SEQ ID ~~No. 1~~ <sup>NO:1</sup>

            - ~~and~~ that starting at nucleotide 1266 and ending at nucleotide 2207 <sup>OF SEQ ID NO:1</sup>

15           and especially the DNA or RNA fragments whose sequence has, for any succession of 30 contiguous monomers, at least 50%, preferably at least 60%, or better still at least 85% homology with any one of said sequences.

20           The subject of the invention is also a protein, called Ptc100 by the applicant, having an apparent molecular mass of about 100 kDa, which is recognized by anti-Trypanosoma cruzi antisera, or an immunological equivalent of this protein, and fragments thereof. The  
25           amino acid sequence of this protein is represented in the identifier sequence SEQ ID ~~No. 2~~ <sup>NO:2</sup>

            Immunological equivalent is understood to mean any polypeptide or peptide capable of being immunologically recognized by the antibodies directed against  
30           said Ptc100 protein.

            The invention also relates to any fragment of the Ptc100 protein. A particular protein fragment has a

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sequence starting at amino acid 323 and ending at amino  
acid 520 of the sequence defined in the identifier SEQ  
ID ~~NO 12~~ <sup>NO 12</sup> said fragment being specifically recognized by  
anti-Trypanosoma cruzi antisera; the invention also  
5 relates to any immunological equivalent of said  
fragment.

The Ptc100 protein and said protein fragments  
may contain modifications, especially chemical modifi-  
cations, which do not alter their immunogenicity.

10 Moreover, the subject of the present invention  
is also an expression cassette which is functional  
especially in a cell derived from a prokaryotic or  
eukaryotic organism, and which allows the expression of  
DNA encoding the entire Ptc100 protein or a fragment  
15 thereof, in particular of a DNA fragment as defined  
above, placed under the control of elements necessary  
for its expression; said protein and said protein frag-  
ments being recognized by anti-Trypanosoma cruzi anti-  
sera.

20 Generally, any cell derived from a prokaryotic  
or eukaryotic organism can be used within the framework  
of the present invention. Such cells are known to  
persons skilled in the art. By way of examples, there  
may be mentioned cells derived from a eukaryotic  
25 organism, such as the cells derived from a mammal,  
especially CHO (Chinese Hamster Ovarian) cells; insect  
cells; cells derived from a fungus, especially a uni-  
cellular fungus or from a yeast, especially of the  
strain Pichia, Saccharomyces, Schizosaccharomyces and  
30 most particularly selected from the group consisting of  
Saccharomyces cerevisiae, Schizosaccharomyces pombe,  
Schizosaccharomyces malidevorans, Schizosaccharomyces

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sloofiae, Schizosaccharomyces octosporus. Likewise,  
among the cells derived from a prokaryotic organism,  
there may be used, without this constituting a limitation, the cells of a strain of Escherichia coli (E. coli) or enterobacterial cells. A large number of these  
5 cells are commercially available in collections, such as ATCC (Rockville, MA, USA) and AFRC (Agriculture & Food Research Council, Norfolk, UK). The cell may also be of the wild-type or mutant type. The mutations are  
10 described in the literature accessible to persons skilled in the art.

For the purposes of the present invention, an E. coli DH5a cell (marketed by the company CLONTECH under the reference: C2007-1) is used.

15 The expression cassette of the invention is intended for the production of the PTc100 protein or for fragments of said protein which are produced by the abovementioned E. coli cell, and which are recognized by human antisera. Such antisera are obtained from  
20 patients who have contracted a Trypanosoma cruzi infection recently or long ago, and contain immunoglobulins specifically recognizing PTc100. Of course, the PTc100 protein can also be recognized by other antibodies, such as for example monoclonal or poly-  
25 clonal antibodies obtained by immunization of various species with the natural abovementioned protein, the recombinant protein or fragments or peptides thereof.

PTc100 protein is understood to mean the natural Trypanosoma cruzi cytoplasmic antigen, or the  
30 antigen produced especially by the genetic recombination techniques described in the present application, or any fragment or mutant of this antigen, provided

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that it is immunologically reactive with antibodies directed against the PTc100 protein of this parasite.

Advantageously, such a protein has an amino acid sequence having a degree of homology of at least  
5 70%, preferably of at least 85%, and most preferably of  
at least 95% relative to the sequence identified in the  
identifier SEQ ID <sup>NO:2</sup>~~NO:2~~. In practice, such an equivalent  
can be obtained by deletion, substitution and/or  
addition of one or more amino acids of the native or  
10 recombinant protein. It is within the capability of  
persons skilled in the art to perform, using known  
techniques, these modifications without affecting  
immunological recognition.

Within the framework of the present invention,  
15 the PTc100 protein can be modified in vitro, especially  
by deletion or addition of chemical groups, such as  
phosphates, sugars or myristic acids, so as to enhance  
its stability or the presentation of one or several  
epitopes.

20 The expression cassette according to the  
invention allows the production of a PTc100 protein  
(having an amino acid sequence as specified above) and  
fragments of said protein, fused with an exogenous  
element which can help its stability, its purification,  
25 its production or its recognition. The choice of such  
an exogenous element is within the capability of  
persons skilled in the art. It may be especially a  
hapten, an exogenous peptide or a protein.

The expression cassette according to the  
30 invention comprises the elements necessary for the  
expression of said DNA fragment in the cell considered.  
"Elements necessary for the expression" is understood

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to mean the elements as a whole which allow the transcription of the DNA fragment into messenger RNA (mRNA) and the translation of the latter into protein.

The present invention also extends to a vector  
5 comprising an expression cassette according to the invention. This may be a viral vector and especially a vector derived from a baculovirus, more particularly intended for expression in insect cells, or an adeno-virus-derived vector for expression in mammalian cells.

10 It may also be an autonomously replicating plasmid vector and in particular a multiplicative vector.

The present invention also relates to a cell derived from a prokaryotic or eukaryotic organism,  
15 comprising an expression cassette, either in a form integrated in the cellular genome, or inserted in a vector. Such a cell was previously defined.

The subject of the present invention is also a process for preparing a PTc100 protein, or fragments of  
20 said protein, according to which:

(i) a cell derived from a prokaryotic or eukaryotic organism, comprising the expression cassette according to the invention, is cultured under appropriate conditions; and

25 (ii) the expressed protein derived from the abovementioned organism is recovered.

The present invention also relates to one or more peptides, whose amino acid sequence corresponds to a portion of the sequence of the PTc100 protein and  
30 exhibiting, alone or as a mixture, a reactivity with the entire sera from individuals or animals infected with Trypanosoma cruzi.

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The peptides can be obtained by chemical synthesis, lyses of the PTc100 protein or by genetic recombination techniques.

5 The invention also relates to monoclonal or polyclonal antibodies obtained by immunological reaction of a human or animal organism to an immunogenic agent consisting of the natural or recombinant PTc100 protein and fragments thereof, or of a peptide, as defined above.

10 The present invention also relates to a reagent for the detection and/or monitoring of a Trypanosoma cruzi infection, which comprises, as reactive substance, a PTc100 protein as defined above, or fragments thereof, a peptide or a mixture of peptides as  
15 defined above, or at least one monoclonal or polyclonal antibody as described above.

The above reagent may be attached directly or indirectly to an appropriate solid support. The solid support may be especially in the form of a cone, a  
20 tube, a well, a bead and the like.

The term "solid support" as used here includes all materials on which a reagent can be immobilized for use in diagnostic tests. Natural or synthetic materials, chemically modified or otherwise, can be  
25 used as solid supports, especially polysaccharides such as cellulose-based materials, for example paper, cellulose derivatives such as cellulose acetate and nitrocellulose; polymers such as vinyl chloride, polyethylene, polystyrenes, polyacrylate or copolymers such as  
30 polymers of vinyl chloride and propylene, polymers of vinyl chloride and vinyl acetate; styrene-based copoly-

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mers, natural fibers such as cotton and synthetic fibers such as nylon.

Preferably, the solid support is a polystyrene polymer or a butadiene/styrene copolymer. Advantageously, the support is a polystyrene or a styrene-based copolymer comprising between about 10 and 90% by weight of styrene units.

The binding of the reagent onto the solid support may be performed in a direct or indirect manner.

Using the direct manner, two approaches are possible: either by adsorption of the reagent onto the solid support, that is to say by noncovalent bonds (principally of the hydrogen, Van der Waals or ionic type), or by formation of covalent bonds between the reagent and the support. Using the indirect manner, an "anti-reagent" compound capable of interacting with the reagent so as to immobilize the whole onto the solid support can be attached beforehand (by adsorption or covalent bonding) onto the solid support. By way of example, there may be mentioned an anti-PTcl00 antibody, on the condition that it is immunologically reactive with a portion of the protein different from that involved in the reaction for recognizing the antibodies in the sera; a ligand-receptor system, for example by grafting onto the PTcl00 protein a molecule such as a vitamin, and by immobilizing onto the solid phase the corresponding receptor (for example the biotin-streptavidin system). Indirect manner is also ~~understood~~ <sup>understood</sup> to mean the preliminary grafting or fusion by genetic recombination of a protein, or a fragment of this protein, or of a polypeptide, to one end of the

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PTc100 protein, and the immobilization of the latter onto the solid support by passive adsorption or covalent bonding of the protein or of the polypeptide grafted or fused.

5           The invention also relates to a process for the detection and/or monitoring of a Trypanosoma cruzi infection in a biological sample, such as a blood sample from an individual or an animal likely to have been infected with Trypanosoma cruzi, characterized in  
10   that said sample and a reagent as defined above are placed in contact, under conditions allowing a possible immunological reaction, and the presence of an immune complex with said reagent is then detected.

          By way of non-limiting example, there may be  
15   mentioned the sandwich-type detection process in one or more stages, as especially described in patents FR 2,481,318 and FR 2,487,983, which consists in reacting a first monoclonal or polyclonal antibody specific for a desired antigen, attached onto a solid support,  
20   with the sample, and in revealing the possible presence of an immune complex thus formed using a second antibody labelled by any appropriate marker known to persons skilled in the art, especially a radioactive isotope, an enzyme, for example peroxidase or alkaline  
25   phosphatase and the like, using so-called competition techniques well known to persons skilled in the art.

          The subject of the invention is also an active immunotherapeutic composition, especially a vaccinal preparation, which comprises as active ingredient, a  
30   natural or recombinant PTc100 protein or fragments thereof, or the peptides identified above, the active ingredient being optionally conjugated with a pharma-

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ceutically acceptable carrier, and optionally an excipient and/or an appropriate adjuvant.

The present invention also covers a pharmaceutical composition intended for the treatment or for  
5 the prevention of a Trypanosoma cruzi infection in man or in an animal, comprising a therapeutically effective quantity of an expression cassette, a vector, a cell derived from a prokaryotic or eukaryotic organism as defined above, a PTc100 protein according to the  
10 invention, or fragments thereof, or an antibody of the invention.

The subject of the present invention is also probes and primers specific for T. cruzi, and their uses in diagnostic tests.

15 The term probe as used in the present invention refers to a DNA or RNA containing at least one strand having a nucleotide sequence which allows hybridization to nucleic acids having a nucleotide sequence as represented in the identifier SEQ ID ~~No. 1~~ <sup>NO:1</sup> or a complementary or antisense sequence, or a sequence equivalent to  
20 said sequence, and especially a sequence having, for any succession of 5 to 100 contiguous monomers, at least 50%, preferably at least 60%, or even better at least 85% homology with SEQ ID ~~No. 1~~ <sup>NO:1</sup> with fragments  
25 thereof, or with a synthetic oligonucleotide allowing such a hybridization, nonmodified or comprising one or more modified bases such as inosine, 5-methyldeoxycytidine, deoxyuridine, 5-dimethylaminodeoxyuridine, 2,6-diaminopurine, 5-bromodeoxyuridine or any other modified  
30 base. Likewise, these probes may be modified at the level of the sugar, namely the replacement of at least one deoxyribose with a polyamide (P. E. NIELSEN

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et al. (1991) (13)), or at the level of the phosphate group, for example its replacement with esters, especially chosen from esters of diphosphate, of alkyl and arylphosphonate and of phosphorothioate.

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5           The probes may be much shorter than the sequence identified in the identifier SEQ ID ~~No. 1~~ <sup>NO: 1</sup>. In practice, such probes comprise at least 5 monomers, advantageously from 8 to 50 monomers, having a hybridization specificity, under defined conditions, to form  
10 a hybridization complex with DNA or RNA having a nucleotide sequence as defined above.

A probe according to the invention can be used for diagnostic purposes as capture and/or detection probe, or for therapeutic purposes.

15           The capture probe can be immobilized on a solid support by any appropriate means, that is to say directly or indirectly, for example by covalent bonding or passive adsorption.

20           The detection probe is labelled by means of a marker chosen from radioactive isotopes, enzymes especially chosen from peroxidase and alkaline phosphatase, and those capable of hydrolyzing a chromogenic, fluorigenic or luminescent substrate, chromophoric chemical compounds, chromogenic, fluorigenic or  
25 luminescent compounds, nucleotide base analogs, and biotin.

3           The probes of the present invention which are used for diagnostic purposes can be used in any known hybridization <sup>technique</sup> ~~techniques~~, and especially the so-called  
30 "Dot-Blot" technique (Maniatis et al. (1982) (14)), <sup>the</sup> Southern Blotting technique (Southern E. M. (1975) (15)), <sup>the</sup> Northern Blotting technique, which is a

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technique identical to the Southern Blotting technique but which uses RNA as target, <sup>and the</sup> sandwich technique (Dunn A.R. et al. (1977) (16)). Advantageously, the sandwich ~~technique~~ <sup>technique</sup> is used which comprises a specific capture probe and/or a specific detection probe, it being understood that the capture probe and the detection probe must have a nucleotide sequence which is at least partially different.

Another application of the invention is a therapeutic probe for treating infections due to Trypanosoma cruzi, said probe being capable of hybridizing in vivo with the DNA or RNA of the parasite to block the <sup>translation</sup> ~~trans-lation~~ and/or transcription and/or replication <sup>phenomena</sup> ~~pheno-mena~~.

A primer is a probe comprising 5 to 30 monomers, having a hybridization specificity, under predefined conditions, for the initiation of an enzymatic polymerization, for example in an amplification technique such as PCR (Polymerase Chain Reaction), in an elongation process such as sequencing, in a reverse transcription method and the like.

A preferred probe or primer will contain a nucleotide sequence chosen from the sequences SEQ ID ~~NO:7~~ <sup>NO:7</sup> SEQ ID ~~NO:8~~ <sup>NO:8</sup> SEQ ID ~~NO:9~~ <sup>NO:9</sup> SEQ ID ~~NO:10~~ <sup>NO:10</sup> ~~NO:11~~ <sup>NO:11</sup> SEQ ID ~~NO:12~~ <sup>NO:12</sup> ~~NO:13~~ <sup>NO:13</sup>.

The invention also relates to a reagent for detecting and/or identifying Trypanosoma cruzi in a biological sample, comprising at least one probe as defined above, and in particular a capture probe and a detection probe, either or both corresponding to the above definition.

The invention therefore provides a process for selectively detecting and/or for identifying Trypanosoma cruzi in a biological sample, according to which the RNA, extracted from the parasite and optionally  
5 denatured, or the DNA, denatured extract, or the DNA obtained from reverse transcription of the RNA, is exposed to at least one probe as defined above and the hybridization of said probe is detected.

The invention will be understood more clearly  
10 upon reading the detailed description below which is made with reference to the accompanying figures in which:

DESCRIPTION OF THE FIGURES

Figure 1 represents the restriction map of the Tc100 gene, which map is deduced by Southern blotting  
15 of different fragments obtained after digestion of Trypanosoma cruzi DNA with restriction endonucleases.

Figure 2 is a schematic representation of the three overlapping regions of the Tc100 cDNA. The numbered arrows represent the oligonucleotides used as  
20 primers for the PCR amplification.

Example 1: Isolation of the Tc50 clone

An expression library was constructed from  
25 Trypanosoma cruzi genomic DNA fragments. The T. cruzi, strain G (YOSHIDA. N, (1983) (17)), DNA isolated from the metacyclic trypomastigote stage was digested with the enzyme DNase I. After selection of the fragments according to their size, they were ligated to synthetic  
30 EcoRI adaptors and cloned into the EcoRI site of lambda gtl1 vector DNA (Young and Davis, 1983 (3); Cotrim et al., 1990) (4).

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The clone, called Tc50 by the applicant, was isolated from the library by immunological screening with the aid of a mixture of sera from patients suffering from the chronic phase of the Chagas disease.

5 The Tc50 phage clone was purified, amplified and the insert was detected by the PCR ("Polymerase Chain Reaction") technique with the aid of the primers:

SEQ ID ~~No. 3~~ <sup>NO:3</sup> 5' (GGTGGCGACGACTCCTGGAGCCCG) 3' <sup>24</sup> ~~24~~

and

10 SEQ ID ~~No. 4~~ <sup>NO:4</sup> 5' (TTGACACCAGACCAACTGGTAATG) 3' <sup>24</sup> ~~24~~,  
corresponding respectively to the nucleotide sequence of the left and right arms of the lambda gt11 phage DNA.

15 The 594 base pairs (bp) Tc50 DNA fragment, after EcoRI digestion, was subcloned into the expression vector pGEX (Pharmacia) linearized with EcoRI. The sequencing of the Tc50 clone DNA was carried out in this same vector with the aid of specific primers situated in 3' and 5' of the cloning site of  
20 pGEX, according to the chain termination technique (Sanger et al., 1977 (5)) and according to the manufacturer's procedure (USB-Amersham).

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25 The nucleotide sequence of the 594 bp Tc50 fragment as well as its deduced amino acid sequence (198 aa) are represented in the identifiers SEQ ID ~~No. 1~~ <sup>NO:1</sup> and SEQ ID ~~No. 2~~ <sup>NO:2</sup> respectively. The nucleotide sequence of the 594 bp Tc50 fragment starts at nucleotide (nt) 1232 and ends at nucleotide 1825 <sup>OF SEQ ID NO:1</sup> ~~No. 1~~. The corresponding amino acid sequence starts at amino acid 323 and ends  
30 at amino acid 520 of SEQ ID ~~No. 2~~ <sup>NO:2</sup>.

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Example 2: Expression of the Tc50 clone in Escherichia coli

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The construct pGEX-Tc50 (198 aa) synthesizes,  
5 in the bacterium DH5alpha, a protein fused with GST  
("Glutathione S Transferase"), with an apparent mole-  
cular mass of 50 kDa, which is detected by SDS-PAGE  
polyacrylamide gel electrophoresis (SDS: sodium dodecyl  
sulfate) (Laemmli, 1970 (6)). The reactivity of the  
10 protein towards chagasic human sera was confirmed by  
the Western blotting technique (Towbin et al., 1979  
(7)) with the aid of the same mixture of chronic phase  
chagasic sera which is used for screening the lambda  
gt11 library.

15 The soluble fraction of the recombinant GST-  
Tc50 protein obtained after lysis of the bacterial  
extracts by ultrasound was purified by affinity  
chromatography on a glutathione agarose column (Sigma),  
according to the method of Smith and Johnson, (1988)  
20 (8).

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The antigenic properties of the recombinant  
GST-Tc50 antigen were tested by ELISA (Voller et al.,  
1975 (9)). <sup>Microtiter</sup> ~~For that, microtiter~~ plates (Maxisorp (trade  
name)) ~~name), nunc)~~ were sensitized with 100 ng/ml of GST-Tc50  
25 antigen in 100 mM NaHCO3 (pH 9.6). After incubation  
with the patients' sera, the immune complexes were  
detected with the aid of a peroxidase-coupled anti-  
human IgG goat serum.

30 The results are presented in the accompanying  
table and show that the ~~entire~~ <sup>reacts</sup> chagasic human sera  
tested ~~react~~ specifically with the recombinant protein.  
No cross-reactivity was observed on 7 sera from

patients suffering from cutaneous or visceral leishmaniasis.

5     Example 3: Identification of the native T. cruzi protein having the antigenic determinants of the Tc50 clone

10     The detection of the native T. cruzi protein was performed after immunopurification of a mixture of chagasic human sera on the corresponding recombinant protein called PTc50 by the applicant.

15     The eluate of monospecific polyclonal antibodies which is obtained was used as probe, in Western blotting, on total protein extracts of different stages of the parasite. The selected antibodies specifically reacted with a protein of apparent molecular mass 100 kDa, called PTc100 by the applicant, which is expressed in all the tested strains of the parasite.

20     Example 4: Molecular analysis of the Tc100 gene -Southern blots

25     In order to establish the restriction map of the Tc100 gene (Figure 1), the T. cruzi, strain G, nuclear DNA was digested with different restriction endonucleases (BamHI, EcoRI, HindIII, PstI, PvuII, SacI, BamHI/EcoRI, BamHI/PvuII, EcoRI/HindIII, EcoRI/PstI, EcoRI/PvuII, EcoRI/SacI, PstI/SacI, PstI/PvuII, PvuII/SacI, PvuII/HindIII), separated on agarose gel and then transferred onto a nylon filter according to the Southern technique. The Southern blot hybridization was performed with the 594 bp <sup>Tc50</sup>~~Tc-50~~ DNA, which is a fragment of the Tc100 DNA described above,

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radiolabelled with  $^{32}\text{P}$  by random incorporation (Amersham).

- Cloning of a 3500 bp Tc100 genomic fragment

5 According to the results obtained by Southern blotting, the *T. cruzi*, strain G, genomic DNA was digested with the enzyme EcoRI and then separated on agarose gel. The EcoRI restriction fragments of about 3500 bp (Figure 1) were cloned into the vector lambda gt10 (Huynh et al., 1984 (10)) linearized by EcoRI. The  
10 phage clone containing the 3500 bp Tc100 genomic insert was isolated with the aid of the 594 bp radiolabelled probe described above. A 1041 bp fragment situated in the 3' region of the 3500 bp Tc100 genomic insert was  
15 sequenced. This sequencing was carried out gradually with the aid of the following primers:

NO:5  
SEQ ID NO:5 5' (TCGGGCACTGACGCGGCG) 3' 18  
NO:6  
SEQ ID NO:6 5' (CTTATGAGTATTTCTTCCAGGGTA) 3' 24

20 The primer SEQ ID NO:5 is situated in the previously sequenced portion of the 594 bp Tc50 fragment. The primer SEQ ID NO:6 corresponds to the lambda gt10 phage primer.

25 This 1041 bp fragment, which starts at nucleotide 1403 and ends at nucleotide 2443 of SEQ ID NO:1, has an open reading frame in phase with the sequence of the 594 bp Tc50 fragment.

Example 5: Cloning of the Tc100 cDNA

The cDNA was synthesized from total RNA from T. cruzi, strain G, epimastigots. The Tc100 cDNA was amplified by the PCR technique in three different fragments: a fragment A corresponding to the 5' region of 1459 bp, a fragment B corresponding to the central region of 942 bp, a fragment C corresponding to the 3' region of 1406 bp of the Tc100 cDNA, as schematically represented in Figure 2.

- Cloning of fragment A of the Tc100 cDNA

The total cDNA synthesized by AMV ("avian myeloblastosis virus") reverse transcriptase, with the aid of random hexanucleotides (Boehringer Mannheim), was amplified, by PCR, using the following pair of primers:

SEQ ID ~~NO:7~~ <sup>NO:7</sup> 5' (AACGCTATTATTAGAACAGTT) 3' 21, and  
SEQ ID ~~NO:8~~ <sup>NO:8</sup> 5' (TGCAGCAGCGGCAGAAAGT) 3' 18

SEQ ID ~~NO:7~~ <sup>NO:7</sup> corresponds to a portion of the consensus sequence of 35 nucleotides present in 5' of the mRNAs in trypanosomatids and called "spliced leader" (Parsons et al. 1984 (11)).

SEQ ID ~~NO:8~~ <sup>NO:8</sup> corresponds to the sequence complementary to a portion of the predetermined sequence of the 594 bp fragment, <sup>which</sup> and starts at nucleotide 1442 and ends at nucleotide 1459 of SEQ ID ~~NO:1~~ <sup>NO:1</sup>, according to the coding strand numbering.

After verification by Southern blotting with the aid of the radiolabelled 594 bp probe previously described, the 1459 bp cDNA fragment corresponding to

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the 5' region of Tc100 was cloned into the plasmid called pCRII (trade name) (Invitrogen), and sequenced. The sequence represented in the identifier SEQ ID ~~No. 1~~ <sup>No. 1</sup> starts at nucleotide 1 and ends at nucleotide 1459.

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- Cloning of fragment B of the Tc100 cDNA

The T. cruzi total cDNA was amplified by PCR with the aid of the primers:

SEQ ID ~~No. 9~~ <sup>No. 9</sup> : 5' (CAGCCGACGGTAGCTGCGTCCT) 3' 22

10 and

SEQ ID ~~No. 10~~ <sup>No. 10</sup> : 5' (ACATAATGGCCTCGTTCACAC) 3' 21

The sequence ID ~~No. 9~~ <sup>No. 9</sup> which corresponds to a portion of the 594 bp predetermined sequence of the Tc100 gene starts at nucleotide 1266 and ends at nucleotide 1287 of SEQ ID ~~No. 1~~ <sup>No. 1</sup>.

The sequence SEQ ID ~~No. 10~~ <sup>No. 10</sup> corresponds to the sequence complementary to a portion of the 1041 bp previously described sequence of the Tc100 gene. <sup>The portion</sup> ~~This~~ complementary to ~~sequence~~ <sup>sequence</sup> SEQ ID ~~No. 10~~ <sup>No. 10</sup> starts at nucleotide 2187 and ends at nucleotide 2207 of SEQ ID No. 1, according to the coding strand numbering.

The fragment obtained, 942 bp in length, was cloned into the plasmid pCRII and sequenced. The sequence represented in the identifier SEQ ID ~~No. 1~~ <sup>No. 1</sup> starts at nucleotide 1266 and ends at nucleotide 2207.

- Cloning of fragment C of the Tc100 cDNA

In order to isolate the 3' portion of the Tc100 cDNA, the T. cruzi total cDNA was synthesized with the aid of the adaptor oligo(dT)<sub>16</sub> hybrid primer.



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Of course, since the DNA sequence of the gene has been fully identified, it is possible to produce the corresponding DNA solely by chemical synthesis, and then to insert the DNA into commercially available DNA  
5 vectors, using known techniques from the technology relating to genetic recombination.

TABLE

Disease	Sera	OD (492nm) detection threshold = 0.320
CHAGAS DISEASE	1	1.358 (+)
	2	1.278 (+)
	3	0.328 (+)
	4	0.404 (+)
	5	1.378 (+)
	6	1.059 (+)
	7	0.895 (+)
	8	1.791 (+)
	9	1.635 (+)
	10	1.427 (+)
	11	1.009 (+)
	12	1.743 (+)
	13	0.530 (+)
	14	1.035 (+)
	15	0.461 (+)
CUTANEOUS LEISHMANIOSIS	16	0.291 (-)
VISCERAL LEISHMANIOSIS (Kala azar)	17	0.071 (-)
	18	0.081 (-)
	19	0.279 (-)
	20	0.098 (-)
	21	0.067 (-)
	22	0.125 (-)

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